King's Research Portal

Document Version
Peer reviewed version

Link to publication record in King's Research Portal

Citation for published version (APA):
Woods, A. (2016). Patterns of Animal Disease. In M. Jackson (Ed.), *Routledge History of Disease* (pp. 147-64). Routledge. https://www.routledge.com/The-Routledge-History-of-Disease/Jackson/p/book/9780415720014

Citing this paper
Please note that where the full-text provided on King's Research Portal is the Author Accepted Manuscript or Post-Print version this may differ from the final Published version. If citing, it is advised that you check and use the publisher's definitive version for pagination, volume/issue, and date of publication details. And where the final published version is provided on the Research Portal, if citing you are again advised to check the publisher's website for any subsequent corrections.

General rights
Copyright and moral rights for the publications made accessible in the Research Portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognize and abide by the legal requirements associated with these rights.

•Users may download and print one copy of any publication from the Research Portal for the purpose of private study or research.
•You may not further distribute the material or use it for any profit-making activity or commercial gain
•You may freely distribute the URL identifying the publication in the Research Portal

Take down policy
If you believe that this document breaches copyright please contact librarypure@kcl.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.

Download date: 05. May. 2023

Patterns of animal disease

Abigail Woods

Animal disease is a key shaper and product of human, animal and environmental history. Its emergence and spread can be traced to the ecological relationships between animals and their environments, and to the ways in which humans have used and manipulated them to better serve human ends. Disease not only impacted on animal health and well-being. Heavy human dependence on animals for food, income, transport, companionship, military strength, cultural capital and the creation of scientific knowledge, meant that it also had profound ramifications for human society, politics, economics, health, science and nutrition.

These disease dynamics and their historical significance are increasingly recognised by historians. While short, descriptive accounts of animal disease have long featured in histories of war, agriculture, colonialism, politics and economics, the last ten to fifteen years have witnessed a considerable expansion in dedicated, critical historical literature. This chapter will review works published in the English language. Building on earlier analyses[1], it opens with some general historiographical reflections on the scope of the field and its sources, themes and approaches. It then offers a summary of the current state of knowledge before concluding with some suggestions for future lines of enquiry.

It is perhaps inevitable that when studying patterns of animal disease, historians have focused on those that left the most prominent historical records. These records are largely text-based. Many were created in response to highly dramatic or problematic disease events that affected animals valued by humans and amenable to human surveillance and control. Governments and scientific institutions produced particularly voluminous records. Their use has resulted in a rather uneven historical picture, which privileges the relatively small number of high-profile diseases that inspired scientific and policy responses, in Western and colonial settings during the eighteenth, nineteenth and early twentieth centuries.

Insights into different diseases, times and places, are offered by other historical source materials that historians are only just beginning to tap. Texts devoted to the understanding and cure of sick animals, such as manuscripts, books, the records of veterinary practices, drug recipes and advertisements, offer oblique glimpses into the types of diseases that affected animals from the medieval period to the present day.[2] Oral histories offer a counterbalance to recent official and scientific narratives by revealing the disease perceptions and experiences of animal keepers and healers.[3] Novel perspectives on the identities and impacts of medieval animal diseases are offered by inter-disciplinary analyses that utilise paleopathology, molecular clock analysis and climatic data alongside textual sources.[4]

For medieval historians, the paucity of textual sources favours a European, inter-regional approach to livestock disease.[5] For the opposite reason, modern historians tend to use the colonial or nation state as their dominant frame of analysis. This is in spite of the propensity of infectious diseases to cross national borders, and the late nineteenth and twentieth century growth of international organisations for their control.[6] Like the administrations they study, modern historians frame animal disease as a problem of political economy, public health or (for Colonial Africa) land use. They usually examine diseases singly, in biographical fashion, focusing particularly on the scientists who investigated them, and the officials and veterinarians involved in the development and implementation of vertical control measures. Animal keepers feature largely as the targets or opponents of these policies. Their contributions to disease control, and those made by privately funded scientists, industrial corporations and expert advisors are historically neglected, along with the experiences of the animal victims. The UK, USA and South Africa are particularly well studied. There are some analyses of disease patterns in Canada, Western Europe, Sub-

Saharan Africa, Australia and New Zealand, but little is known about Asia, Latin America and Eastern Europe.

The animal disease represented most frequently in the historical literature is the cattle plague or rinderpest, an extremely fatal and contagious disease that swept repeatedly across the globe before its elimination in 2011. Other highly visible disease outbreaks amongst domestic animals, and diseases that spread to humans via meat and milk consumption, are also well described, to the neglect of less dramatic disease events and those which fell beyond the purview of the state. Cows dominate the literature. Horse diseases are touched upon in some recent accounts, but have attracted less dedicated attention than one might expect given their significance to transport and the military.[7] Sheep and pigs feature infrequently, and despite a burgeoning literature on the history of dogs, analysis of dog diseases is largely confined to rabies.[8] Cat and bird diseases are virtually absent from the historiography, and wildlife feature only when their health impacted on human concerns.[9] Although the health of laboratory animals was recognised as a problem by early twentieth century scientists, the diseases they suffered have not been studied.[10]

Distinctive approaches to animal diseases can be identified within different historical sub-fields. Medical historians tend to follow Charles Rosenberg in approaching animal disease as a social and biological phenomenon.[11] They examine how the manifestations, interpretations of, and responses to disease were moulded both by its epidemiological and clinical characteristics and the wider social, economic and political milieux. By contrast, medieval historians are particularly concerned with reaching a retrospective disease diagnosis and often employ inter-disciplinary methodologies to achieve this goal.[12] Environmental and economic historians often ‘black box’ disease conceptions and focus instead upon the spread of contagion and its effects. Environmental historians also study the ecological relationships between disease and its environments, but their considerations rarely extend to Western contexts and indoor animal environments. Some historians use animal disease to mount a critique of colonialism. They argue that devastating disease events were precipitated by colonial rule, and managed in ways that advanced colonial interests at the expense of indigenous peoples.[13] Other colonial historians challenge this stance by claiming that there was no simple dichotomy between indigenous and settler interests, knowledges and practices, and that all could benefit from disease control.[14]

For heuristic purposes, the following summary will divide animal diseases into four categories: epizootics, zoonoses, other infectious diseases and non-communicable diseases. These categories are widely recognised today. They also existed loosely in the past, although their exact definitions and labels have changed over time.[15] They are rooted partly in the epidemiological characteristics of disease: epizootics are animal epidemics, and zoonoses spread between humans and animals. They are also social constructs that reflect the framing and management of particular diseases at specific points in time. Epizootics have potentially devastating effects on animal health, while zoonoses diseases threaten human health. Both are more likely to be perceived as public problems in need of state and scientific intervention than lower-profile infections and non-communicable diseases. Diseases can also move between categories as social, political, economic and scientific developments reshape their understanding and measures adopted for their control.[16]

Epizootic diseases

Owing to their high visibility and often devastating effects, epizootic diseases have been recorded since antiquity.[17] While their contagious nature was widely recognised, prior to the late nineteenth century they were also believed to generate spontaneously owing to the influence of the atmosphere and the conditions in which animals were kept.[18] This notion was eventually dispelled by the germ theory, the efficacy of quarantine regulations, and the discovery, particularly in tropical regions at the turn of the twentieth century, that some diseases had insect and tick vectors whose distribution influenced disease geography.[19]

At least eight major outbreaks of cattle epizootics occurred in early post-classical Europe, although their identity is difficult to discern.[20] There was also a severe horse epizootic, retrospectively diagnosed as Eastern Equine Encephalomyelitis, which killed 90% of Charlemagne's heavy war-horses in 791-3 AD, and prevented him from waging war as he did in virtually every other year of his reign.[21] Like subsequent epizootics, these were spread by, and impacted on trade, human migration, and military campaigns. Extreme weather and climatic anomalies may also have played a role by creating food shortages that undermined disease resistance and prompted migration.[22] During the nineteenth century, the development of railways and steamships, the rise of free trade, colonial conquest and commerce, and the growth of urban populations, resulted in more frequent, long-distance animal movements that intensified epizootic disease spread.[23] Expanding cities were supported by ever-increasing horse populations whose susceptibility to influenza epizootics brought transport to a virtual standstill.[24] Rising demand for milk stimulated the development of overcrowded, insanitary urban dairies which were known 'hot beds' of disease.[25] The development of settler agriculture at the Cape, and the dramatic expansion of sheep grazing there and in New Zealand and Australia, impacted on livestock stocking densities, land use patterns, and the distribution of insect vectors and game reservoirs of disease, all of which contributed to epizootic disease outbreaks.[26]

The most historically significant epizootic disease (although it never became established in the Americas, Australia or New Zealand) was the highly contagious, fatal cattle plague or rinderpest.[27] Earlier claims that this was responsible for devastating European epizootics in 569-70 and 986-88 AD have been challenged by molecular clock analyses, which identify the cause as a now-extinct virus of humans and cattle that subsequently evolved into rinderpest and measles.[28] However, it seems likely that rinderpest was the cause of a fourteenth century, pan-European cattle epizootic. Since cows in medieval society not only supplied meat and milk but also fertiliser and draught power, this ‘Great Bovine Pestilence’ impacted substantially on human nutrition, and potentially increased human vulnerability to subsequent outbreaks of bubonic plague.[29]

While cattle plague epizootics of the fifteenth, sixteenth and seventeeth centuries have not been subjected to critical historical analysis, those of the eighteenth and nineteenth centuries are well documented. Successive waves of the disease hit eighteenth century Europe, killing an estimated 200 million cattle. Appuhn argues that its spread was precipitated by the development of new markets for beef cattle in Western Europe which were supplied by the growth of cattle ranching on the Hungarian plains.[30] The devastating effects of cattle plague stimulated some of the first, organized responses from the state and medical profession. For Wilkinson, they also precipitated the late eighteenth century creation of the veterinary profession, though recent scholarship has shed doubt on this claim.[31]

Inspired by responses to bubonic plague, cattle plague controls aimed to quarantine infected herds, slaughter sick animals and restrict the livestock trade. The evolution and outcome of these measures have been studied for Britain, France, the Netherlands and parts of Germany. Authors conclude that their effectiveness was impeded by public evasion, opposition, and the weakness of the state.[32] An alternative, empirical measure, inoculation, was attempted but failed to displace the so-called ‘stamping out’ method.[33] Around 1800, rinderpest disappeared from Western Europe but remained endemic in Russia and parts of Eastern Europe. During the 1860s it re-invaded. To enable stamping out, governments created permanent veterinary departments which granted vets a state-sanctioned role in contagious animal disease control. In Britain, there were extensive scientific investigations and futile attempts at cure. Stamping out proved unpopular initially, and achieved widespread acceptance only after it had eliminated disease from the nation.[34]

Rinderpest also entered India in the 1860s and spread quickly through South Asia. It was introduced into Africa by the 1888 Italian invasion of Ethiopia, and swept south to reach South Africa in 1896.[35] In parts of Africa, where cattle were a ‘means of production and reproduction, not only of labour power, but of society itself’[36], death rates exceeded 90%, depriving indigenous peoples of fuel, fertiliser, food, clothing, traction and currency. The collapse of transport and the livestock economy prompted the growth of state intervention and veterinary services. Restrictions on the livestock trade were sometimes enforced by military troops, and provoked uprisings by indigenous peoples in certain colonial contexts. At the Cape, the impracticality of stamping out, combined with developments in Western bacteriology, resulted in the application of a new form of inoculation. Developed by Robert Koch, improved upon by local vets and taken up by supportive Anglophone farmers, it changed the course of the rinderpest epidemic, and became compulsory in Rhodesia in 1898.[37] A similar method was adopted in India. By then, the disease had been endemic for over three decades, but the Indian government had made no attempt to control it. For Mishra, this neglect reflected the irrelevance of cattle to the colonial economy and officials’ disregard for the plight of ordinary Indians,[38] However, the propensity of cow slaughter to provoke religious and political unrest was probably also a factor.[39]

The effects of cattle plague were compounded by other epizootic disease outbreaks. In South Africa, the disease known as horse sickness destroyed around 40% of horses in 1854-5. Cavalry regiments were struck down during military campaigns of the 1870s and the South African wars of 1880-1 and 1899-1902. Housing and transhumance (trekking with animals) offered some protection from the midges that were later discovered to spread the disease. Vaccines were developed in the 1930s.[40] Horses and cattle were also killed by nagana (animal trypanosomosis), which Zulu pastoralists tried to avoid through game slaughter, bush clearance and transhumance. Their ideas informed investigations performed by David Bruce in 1894-7, which confirmed the role of tsetse fly vectors and game reservoirs. Rinderpest unexpectedly reduced the prevalence of cattle nagana by killing game, but subsequent efforts to preserve game increased the risk, leading to conflicts between preservationists and settler farmers. Different colonies adopted different strategies for nagana control, ranging from fly catching or trapping to bush clearance, game culling, compartmentalisation of the landscape, and the control of human, livestock and game movements. From the mid-1940s these were largely superseded by DDT spraying, which proved highly effective.[41]

Another unanticipated result of late nineteenth century rinderpest was the appearance in South Rhodesia of the highly fatal, tick-borne, East Coast Fever (ECF), which was imported with replacement cattle from Tanzania. Spreading into North Rhodesia and the Transvaal, it crippled the mining industry, which depended on ox transport. Koch was summoned, but his method of inoculation did not work. Instead, governments adopted livestock dipping and quarantine, and constructed fences to prevent stock moving between ‘clean’ and ‘dirty’ areas.[42] Like other such regulations, they interfered with trade and pasture use. Conspiracy theories abounded, inspiring rebellion in parts of the Transkei in 1914.[43]

Ticks were also implicated in the most devastating animal disease to affect the late nineteenth century USA: tick borne fever. Endemic in Mexico and the American South, it made annual incursions into northern areas, killing nearly all infected cattle. Efforts to bar southern animals from particular states were not particularly effective, and gave way to dipping in the 1890s, after the tick’s role was discovered.[44] Dipping was also used to kill the mite responsible for sheep scab, which caused severe itching and the costly deterioration of wool. In the New World, this disease was a product of the Columbian exchange.[45] Its appearance in 1780s Australia threatened the expansion of sheep farming and led, from the

1830s, to the first Australian animal health laws.[46] During the 1870s, Natal and Cape Colony adopted similar regulations, requiring the isolation and dipping of sheep.[47]

Livestock in Africa suffered from other serious epizootics such as blue tongue, red water, heart water, liver fluke, and contagious bovine pleuro-pneumonia (CBPP, or 'lung-sickness'), which spread globally in the mid-nineteenth century, along with the highly contagious but generally non-fatal foot and mouth disease (FMD). CBPP was introduced into the Cape in 1853 by Dutch cattle and killed around 20% of the cattle population. In the midst of colonial conflict and social change, it gave rise to a Xhosa prophesy that the active killing of cattle would cause the dead to rise, white man to perish, and new cattle to issue from the earth. Chiefs put this measure into effect in 1856, but the prophesy was not fulfilled and enormous hardship ensued.[48] Colonialists sometimes tried to control CBPP by inoculation, as devised by Belgian physician, Louis Willems in the 1840s, but although it produced some immunity it could also transfer infection.[49] Stamping out was adopted at the Cape in 1881, and in the USA in 1884 with eradication declared just eight years later.[50] Britain also opted for stamping out,[51] but other countries used inoculation to control CBPP, either alone (as in New Zealand, where it disappeared within a decade of its 1863 introduction from Australia),[52] in combination with stamping out (eg Australia),[53] or as a means of reducing incidence to a point at which stamping out became possible. By 1900, CBPP had been controlled if not eliminated from many Western countries.[54]

In Britain, stamping out was applied to FMD from 1869, and extended in 1878 to swine fever, a fatal epizootic of pigs. As these were familiar, endemic problems with low mortality (FMD) and variable symptoms (swine fever), many stockowners questioned whether the benefits outweighed the costs.[55] However in 1886, FMD was eliminated and thereby transformed into a dreaded, alien plague. It reappeared frequently over the next 80 years, causing occasional, devastating epidemics. In early twentieth century Germany, France, Holland and Italy, serum was the preferred method of FMD and swine fever control. Effective vaccines became available mid-century and enabled some countries to progress to stamping out.[56] However, FMD remained endemic in parts of Africa, Latin America and Asia. An epidemic in Mexico, 1946-52, led to US assistance in stamping out, and generated new appointments of state veterinarians, and the improvement of veterinary education and research.[57] In 1992, with disease at a low ebb, FMD vaccination was halted throughout the EU in favour of stamping out. This left the region vulnerable to a devastating epidemic, which struck in 2001 following a global resurgence of FMD.[58]

When selecting epizootic control policies, governments bore in mind the likely costs and benefits, the chances of success, and the public response. Stamping out aimed to eradicate disease from regions or nations, while disease control was the object of inoculation, serum treatment, vaccination, dipping and cordon sanitaires. The latter measures were imposed with varying degrees of compulsion and depended on effective biological products, which were generally developed within state laboratories such as Onderstepoort Veterinary Institute in South Africa.[59] Stamping out was primarily adopted by rich nations that were geographically remote from epicentres of infection and had low to moderate disease incidence. It required well-defined, easily policed borders, well-resourced veterinary services, and compliant publics who were prepared to report suspect cases and abide by controls. It appealed especially to importing nations that were both vulnerable to disease invasion and capable of imposing sanitary standards upon their trading partners. These partners frequently challenged these measures. They claimed – not without reason – that sanitary regulations were applied for political reasons or to protect domestic producers.[60] During the early twentieth century there were attempts to resolve such conflicts through an internationally agreed system of trade controls, but it was decades before a workable system came into operation under the Office International des Epizooties.[61]

The costs and benefits of control policies were not distributed equitably. Some parties had more power than others to define the disease problem and its manner of its solution. For example, British FMD control policy was shaped by elite breeders, and privileged their interests over grass roots producers, whose protests resurfaced in every major epizootic up to and including 2001.[62] Likewise, Olmstead and Rhodes note the uneven impacts of US policy, and the resistance generated, but conclude that state actions were justified given the overarching benefits of disease control.[63] The actions of colonial states often involved incursions into traditional husbandry practices. In the Cape, official attempts to control disease through livestock movement restrictions actually undermined traditional methods of disease avoidance though transhumance.[64] For Phoofolo, such controls were part of an ongoing colonial strategy to marginalize Africans and subjugate them to colonial rule.[65] Others have tempered this claim. Brown and Gilfoyle argue that while measures were intended to promote white settler agriculture, Africans also benefitted from the diminution of disease.[66] Similarly, Waller claims that policies initially intended to support Kenyan settler elites were subsequently redirected for the benefit of Africans, in response to new scientific understandings and colonial development priorities.[67]

Myxomatosis, a new world disease of rabbits spread by blood sucking insects, is a rare example of a modern epizootic that was allowed to run its course. Although the victims – wild rabbits – had some utility to humans as food and fur, they were more widely regarded as crop-consuming pests. The disease was introduced into New South Wales in 1950 with a view to their destruction. It broke out in continental Europe in 1952, then entered Britain, where farmers were complicit in its spread. Despite the devastating effect on rabbit populations, governments declined to act.[68]

Zoonotic diseases

One of the earliest recognised zoonoses was cowpox. Dairy farmers had long been aware of its capacity to protect humans against smallpox infection, but it was not until Edward Jenner demonstrated this fact (1796) and published his findings (1798) that vaccination became a medical practice, made compulsory by many governments during the nineteenth century.[69] Cowpox was unusual in benefitting human health. Rabies and glanders were fatal, though sporadic. Their capacity to spread from dogs and horses respectively was known by the early nineteenth century, although other origins were proposed. Legislation to control glanders was made more effective by the 1892 discovery of mallein, a diagnostic product that could identify infected but asymptomatic horses. Produced by government laboratories, and applied by civilian and military officials under compulsory test and slaughter policies, it resulted in the eradication of glanders from most of Europe and North America by WWII.[70]

The horrific symptoms of rabies provoked disproportionate fear and panic, leading occasionally to the mass public slaughter of dogs. In the late nineteenth century, several countries passed legislation in the face of owner resistance for the muzzling, quarantine and destruction of dogs. Vaccines were applied from the 1930s.[71] In Southern Africa, where rabies was a predominantly rural and often unreported disease that circulated and spread through livestock and wildlife, there were unsuccessful twentieth century attempts to eradicate the main animal vectors: meerkats and jackals.[72] Similar methods were applied, with similar outcomes, to the rodent vectors of bubonic plague, whose role was identified at the turn of the twentieth century in the context of a devastating pandemic.[73]

Other zoonotic diseases rose to prominence in the mid to late nineteenth century, influenced by the same factors that contributed to epizootic disease spread, and the rising consumption of meat and milk which spread infection.[74] Concurrently, the adoption of germ theories, the growth of epidemiological, pathological and bacteriological research, and the assumption of new state responsibilities for human and animal health, resulted in the identification of new epizootic diseases that were subjected to novel and frequently controversial forms of state intervention.[75]

One such disease was anthrax or ‘splenic fever’, a sporadic but potentially devastating disease of horses, sheep and cattle that was associated with particular soils. During the 1870s and 1880s, scientists discovered that it had the same bacterial cause as two diseases associated with the expanding textile industry in western Europe and the United States: ‘woolsorters disease’ (a fatal pneumonia associated with the growing textile industry) and ‘malignant pustule’ (a skin disease). It transpired that the growth of the global wool trade was exposing Western wool workers to anthrax spores contained in the fleeces of Asian and South African sheep. Anthrax generated a range of responses: disinfection of fleeces and the factory environment, the special burial of animal carcasses, and the use of serum and vaccines. It later resurfaced as a biological weapon for use against animals and humans.[76]

The role of meat in disease transmission was first elucidated for the pork-borne parasitic disease, trichinosis, which could cause death in humans. It was identified in human muscle tissue in 1835, and its life cycle elucidated in 1850-70 by Rudoph Virchow and others. The increasing identification of human deaths prompted various German states to establish public slaughterhouses, where meat was subjected to microscopic inspection for trichinosis, and general veterinary inspection for the detection of other zoonotic and epizootic diseases.[77] This system was taken up by some other European countries and led, from 1879, to restrictions on the importation of suspect pork from the USA. Despite the protests of American officials, Germany lifted its restrictions only in 1891, following the passage of American legislation to require the microscopic inspection of pork for export.[78]

The late nineteenth century development of meat inspection was also driven by fears surrounding bovine tuberculosis (bTB) and its transmissibility to humans. These fears were confirmed in 1882 when Koch announced that TB in humans and animals had the same bacterial cause. Control was problematic because bTB was often very prevalent and clinically evident only in its advanced stages. Butchers, vets and doctors laid rival claims to expertise in the identification and handling of diseased carcasses. Difficulties were compounded by Koch's controversial 1901 announcement that the diseases were not, after all, identical.[79]

By then, attention was turning to bTB transmission via milk. Its role in the spread of human typhoid, scarlet fever and diphtheria had already been postulated by British public health doctors in the 1870s and 80s, in the face of strong opposition from veterinary surgeons and dairy farmers.[80] Fears of bTB added impetus to efforts to improve the sanitary status of milk. However, effective action was frequently impeded by conflict between interested parties, the disconnect between regulatory regimes that had evolved to tackle either human or animal disease, the physical distance between sites of milk consumption and production, the sheer scale of the problem, difficulties in enforcing regulations, conflict over the costs and benefits of milk pasteurisation, and the outbreak of WWI.[81]

Two methods emerged in the late nineteenth century for the control of bTB in cows. German veterinarian, Robert von Ostertag, advocated the clinical identification and slaughter of advanced cases. Danish veterinarian, Bernhard Bang aimed to identify (then isolate or slaughter) infected cows through injections of tuberculin, a diagnostic substance whose effects were often contested. Vaccines were subsequently developed, notably by the Pasteur Institute in inter-war France, where their favourable effects were used to justify the extension of BCG vaccination to children.[82] Government attempts at bTB control typically began with the removal of clinical cases and progressed to the use of tuberculin, initially voluntarily and then on a compulsory basis. Regional measures often preceded national campaigns.[83] The same approach was later applied, in conjunction with vaccination, to the eradication of brucellosis. This disease caused contagious abortion in cows and was discovered, in the 1920s, to spread via milk to cause undulant fever in humans.[84]

The timing and progress of public bTB campaigns were influenced by disease incidence, public attitudes, and governments' willingness to bear the costs. Action was initiated by the Finnish government in 1898. In the USA, where less than 5% of dairy cows were infected, state campaigns began in the 1900s and a federal campaign in 1917. Denmark and the Netherlands followed during the inter-war period. In Britain, where 40% of dairy cows were infected, piecemeal inter-war interventions were superseded in the 1950s by a full-scale eradication campaign. By then, the compulsory pasteurisation of milk had effectively abolished the threat to human health.[85] Fears of trade restrictions imposed by countries that aimed to eliminate bTB drove the 1970s adoption of national eradication schemes in Northern Ireland and Australia.[86] Many of these campaigns were highly successful. However in Britain and New Zealand, early progress was later overturned. Wildlife disease reservoirs – badgers and possums respectively – were held to blame. Possum control proved relatively straightforward, but in Britain, the situation is still unresolved owing to politicisation, disputes over scientific evidence and expertise, and conflicting cultural constructions of the badger.[87]

Co-ordinated efforts to address zoonotic diseases in developing countries began in 1948, with the foundation of a Veterinary Public Health Unit under the World Health Organisation. Working closely with the Food and Agriculture Organisation, its programmes were key vehicles for improving human health and nutrition through improved meat hygiene and zoonotic disease control.[88] Meanwhile, in the West, new zoonotic disease threats were identified. Species of malaria thought specific to monkeys were found to transmit to humans,[89] and the discovery that pigeons could harbour psittacosis fuelled campaigns to remove them from cities.[90] There was an increased risk of food poisoning from inadequately cooked meat and eggs. This arose partly from more intensive farming methods that encouraged the spread of salmonella and campylobacter. Slaughterhouse practices were also to blame. Variable standards of hygiene resulted in the cross-contamination of carcasses, while germs went undetected by traditional, macroscopic inspection methods.[91]

Towards the end of the twentieth century, scientists traced several emerging infections of humans to animals. They discovered that HIV/AIDS had developed from non-human African primates, and SARS from civets. In 1996, they linked a new variant of the fatal human brain disease, CJD, to the consumption of meat from cows suffering from BSE. Also known as mad cow disease, BSE had appeared in Britain a decade earlier. Although the British government took steps to reduce the disease risk to humans, its earlier assurance that meat was safe, and the devastating impact of vCJD on its young victims, generated a crisis of trust in science and the state. Zoonotic disease concerns subsequently shifted to swine and avian influenza, but early twenty-first century fears of a major human pandemic have not as yet been realized.[92]

Other infectious and non-communicable diseases

Despite the historical attention awarded to epizootic and zoonotic diseases, the vast majority of diseases experienced by animals fell outside these categories. Relatively little is known about their histories, particularly in the pre-modern era. They included infections now identified as influenza in cats and distemper, parvo virus and kennel cough in dogs, together with lameness, infertility, respiratory, gastro-intestinal and parasitic diseases in horses and farmed livestock. There were also many non-communicable diseases, including injuries, lameness, infertility, diseases associated with feeding, and chronic conditions like cancer.

Some affected individuals, others populations, and many had complex aetiologies. Their effects ranged from death to symptomatic illness to sub-clinical reductions in performance. Responsibility for their identification and management fell to animal keepers and their expert advisors. While nineteenth and twentieth century governments supported some research into economically important diseases of livestock, they only intervened in disease control under exceptional circumstances, as in WWII, when food shortages led the British government to subsidise practising veterinary surgeons in the control of bovine mastitis and infertility.[93]

The incidence, perception and impacts of these diseases were shaped by the ways in which humans used, managed and valued animals. Paleopathological analysis and the records kept by animal healers reveal the prevalence of wounds and musculo-skeletal problems in horses. This reflects their use as power sources, while the attention paid to breeding difficulties in livestock illustrates how humans relied upon them for meat, milk and profit.[94] Dog owners, alarmed by the death and suffering caused by the infectious disease, distemper, stimulated inter-war British research into the disease and tested the vaccine which resulted.[95] During the later twentieth century, efforts to understand and manage chronic diseases in pets like Feline Urological Syndrome, reveal the growth of humanitarian and consumerist attitudes to these animals. Awarded a similar status to family members, pets became part of a new ‘economy of love’ that encouraged the circulation of surgical techniques between human and veterinary medicine for the management of their shared orthopaedic conditions.[96]

For grazing animals, pasture and its management had important impacts on health. In New Zealand, the poisonous plant, tutu, was known since the pre-colonial period to cause significant losses, estimated for the mid-nineteenth century at 25-75 per cent of sheep flocks.[97] Mineral deficient soils and poisonous plants were identified as causes of disease by the first colonial veterinarians at the Cape. By the early twentieth century, poisonous plants made horse rearing impossible in parts of South Africa, and by 1920, they killed more livestock than infectious disease. In earlier periods, African pastoralists and settlers had used transhumance (trekking) to avoid affected areas, but this was impeded by land privatisation and increased stocking densities.[98] Pastures could also harbour infection, as in colonial New Zealand, where pastoralists encountered the prevalent and costly problem of foot rot in sheep, and responded by breeding new types of sheep that were less susceptible to infection.[99] Known since the eighteenth century, the sheep disease, scrapie was also associated with certain pastures, although infection and heredity were also suggested as causes. Twentieth century scientists demonstrated its communicability, and hypothesised the involvement of an unusual disease agent, the prion, which was subsequently implicated in BSE.[100]

Housed livestock experienced a different set of diseases, whose emergence was associated with the mid to late twentieth century shift towards intensive husbandry regimes. Intensification also enabled greater surveillance of animal bodies that made the effects of disease more visible. Meanwhile, farmers' narrowing profit margins, and (from the 1960s) the emergence of animal welfare agendas, led to the increasing problematisation of disease. This context favoured the growth of disease research, veterinary services, and the development and use of new drugs, notably antibiotics, but these did not always achieve the desired ends.[101] For example, in the case of the dairy cow disease, mastitis, controls developed as a result of scientific research simply enabled farmers to pursue more intensive forms of production which led to the unanticipated emergence of new forms of the disease.[102]

Conclusion

This review offers a snapshot of a field that is advancing rapidly in scope and intellectual ambition. Epizootic and zoonotic disease history is now a well-established genre, underpinned by a substantial body of literature. Authors have probed the emergence, spread, and impacts of these diseases; the linked development of state veterinary services and scientific research; the origins and effects of regulations for their control and the controversies that often ensued. New perspectives are emerging which push beyond existing, state-centred narratives, to examine diseases in previously overlooked parts of the world; their relationships with land use patterns in non-Western contexts; and their identities and impacts within medieval societies. There is still potential to extend these enquiries in space and time to produce truly global histories of animal disease. This will require attention to the under-studied early modern era and post-WWII decades; to regional and international disease impacts and responses; and to epizootic and zoonotic diseases that fell beyond the purview of the state.

However, perhaps the greatest priority for future scholarship is to shift the focus away from the zoonoses and epizootics, towards other infectious and non-communicable animal diseases. Despite a slowly developing trend in this direction, these diseases are still neglected by historians. This is surprising when one considers that such diseases were not only numerous but also difficult to prevent or eliminate. Compared to zoonoses or epizootics – which were exceptional events – they were encountered very frequently and had a more substantial impact on the lives of animals and their keepers. Yet because historians prefer to use easily accessible archives, and have been more interested in scientists and the state than animals and their keepers, zoonotic and epizootic diseases continue to dominate historical scholarship.

Extending the sphere of analysis to everyday diseases offers many exciting possibilities for rewriting the script of animal disease history. It brings wildlife, birds, pets, laboratory, and zoo animals into the picture, as well as their habitats and the people that cared for them, advised upon and investigated their health. It shifts the scale of analysis from the nation state or livestock economy to the farm, stable, household, firm or laboratory. In these settings, diseases were not simply economic or public health problems but also threats to ecosystems, production systems, communities, scientific research, animal well-being, and the human-animal bond. Examining their histories using the variety of source materials outlined in the introduction, will provide new insights into the contexts that gave rise to disease, and the ways in which animal keepers understood and responded to it. Foregrounding these individuals, and approaching them as disease experts rather than subjects, shapers and opponents of government policy, will also assist in the long-overdue production of an animal health history 'from below.'

There is also scope for integrating investigations into animal disease history with other types of disciplinary enquiry. As noted above, medieval historians already draw upon archaeological findings and scientific insights to help interpret their often fragmentary documentary evidence. For Newfield, 'it is via interdisciplinarity that our understanding of past non-human animal health and disease…will improve.'[103] While this approach may appeal less to modern historians, in providing a lens onto the evolution of human-animal relations, agricultural practices and state bureaucracies, their investigations have considerable capacity to inform, and be informed by contemporary studies of these matters. In addition, the integration of historical analysis with social scientific and scientific perspectives offers the prospect of situating current disease patterns within a longer historical trajectory, of identifying the contributing factors, and learning from past attempts to understand and control them. In this way, historians can make their insights relevant to a world in which animal disease continues to threaten human health and nutrition, animal welfare and the environment.

Further reading

Beinart, W., ‘Transhumance, animal diseases and environment in the Cape, South Africa’, *South African Historical Journal* 58, 2007, 17-41.

Brown, K. and Gilfoyle, D. (eds), *Healing the Herds: Disease, Livestock Economies and the Globalization of Veterinary Medicine,* Athens: Ohio University Press, 2010.

Cranefield, P., *Science and Empire: East Coast Fever in Rhodesia and the Transvaal,* Cambridge: Cambridge University Press, 1991.

Fisher, J., ‘To kill or not to kill: The eradication of contagious pleuro-pneumonia in Western Europe’, *Medical History* 47, 2003, 314–31.

Hardy, A., *Salmonella Infections, Networks of Knowledge, and Public Health in Britain, 1880-1975,* Oxford: Oxford University Press, 2014.

Jones, S., *Death in a Small Package: A Short History of Anthrax,* Baltimore: John Hopkins University Press, 2010.

Newfield, T., ‘Domesticates, disease and climate in early post-classical Europe: The cattle plague of c940 and its environmental context’, *Post-Classical Archaeologies* 5, 2015, 95-126.

Olmstead, A. and Rhodes, P., *Arresting Contagion: Science, Policy, and Conflicts over Animal Disease Control*, Cambridge: Harvard University Press, 2015.

Orland, B., ‘Cow’s milk and human disease: Bovine tuberculosis and the difficulties involved in combating animal diseases’, *Food and History* 1, 2003, 179–202.

Pemberton, N. and Worboys, M., *Mad Dogs and Englishmen: Rabies in Britain, 1830-2000* Basingstoke: Palgrave Macmillan, 2007.

Slavin, P., ‘The Great Bovine Pestilence and its economic and environmental consequences in England and Wales, 1318-50’, *Economic History Review* 65, 2012, 1239-1266.

Waddington, K., *The Bovine Scourge: Meat, Tuberculosis and Public Health, 1850–1914,* Woodbridge: Boydell Press, 2006.

Waller, R., "Clean' and 'dirty': Cattle disease and control policy in Colonial Kenya, 1900-14', *Journal of African History* 45, 2004, 45-80.

Woods, A., 'Science, disease and dairy production in Britain, c1927-80', *Agricultural History Review* 62, 2014, 294-314.

Woods, A., *A Manufactured Plague: The History of Foot and Mouth Disease in Britain,* Earthscan: London, 2004.

Notes

[1] K. Brown and D. Gilfoyle, 'Introduction', in K. Brown and D. Gilfoyle (eds), *Healing the Herds: Disease, Livestock Economies and the Globalization of Veterinary Medicine,* Athens: Ohio University Press, 2010, pp. 1-18; S. Mishra, 'Veterinary history comes of age', Introduction to special virtual issue, Social History of Medicine 2014, http://www.oxfordjournals.org/our_journals/sochis/veterinaryhistory.html; T. Newfield, 'Domesticates, disease and climate in early post-classical Europe: The cattle plague of c940 and its environmental context', *Post-Classical Archaeologies* 5, 2015, 95-126.

[2] A. Woods and S. Matthews, ''Little, if at all, removed from the illiterate farrier or cow-leech': The English veterinary surgeon, c. 1860-85, and the campaign for veterinary reform', *Medical History* 54, 2010, 29-54; L. Hill Curth, *"A Plaine and Easie Waie to Remedie a Horse': Equine Medicine in Early Modern England*, Leiden: Brill, 2013; H. A. Shehada, *Mamluks and Animals: Veterinary Medicine in Medieval Islam*, Leiden: Brill, 2013.

[3] W. Beinart and K. Brown, *African Local Knowledge and Livestock Health,* Woodbridge: Boydell and Brewer, 2013; See also the George Ewart Evans collection of interviews, http://sounds.bl.uk/Oral-history/George-Ewart-Evans-collection and the oral history initiatives underway at the University of Minnesota, USA, http://blog.lib.umn.edu/ahc-ohp/ahc-oral-history-project/college-of-veterinary-medicine/ , the Cornell University College of Veterinary Medicine, USA, http://www.vet.cornell.edu/Legacy/PartI.cfm/ and the Royal

College of Veterinary Surgeons, UK, http://knowledge.rcvs.org.uk/grants/awards-made/collaborations/capturing-life-in-practice/ .

[4] R. Thomas, 'Non-human paleopathology', in J. Buikstra and C. Roberts (eds), *The Global History of Paleopathology*, Oxford: Oxford University Press, 2012, pp. 652-64; B. Upex and K. Dobney, 'More than just mad cows: Exploring human–animal relationships through animal paleopathology', in A. Grauer (ed.), *A Companion to Paleopathology*, Chichester: Wiley Blackwell, 2012, pp. 191-213; S. De Witte and P. Slavin, 'Between famine and death: England on the eve of the Black Death – Evidence from paleoepidemiology and manorial accounts', *Journal of Interdisciplinary History* xliv, 2013, 37-60; Newfield, 'Domesticates'.

[5] Newfield, ibid.

[6] P. Zylberman, 'Making food safety an issue: Internationalized food politics and French public health from the 1870s to the present', *Medical history* 48, 2004, 1-28; C. Knab, 'Infectious rats and dangerous cows: Transnational perspectives on animal diseases in the first half of the twentieth century', *Contemporary European History* 20, 2011, 281-306; A. Woods and M. Bresalier, 'One health, many histories', *Veterinary Record* 174, 2014, 650-54.

[7] Curth, *A Plaine and Easie Waie*; G. Winton, *Theirs Not to Reason Why: Horsing the British Army 1875-1925*, Solihull: Helion, 2013.

[8] H. Ritvo, 'Pride and pedigree: The evolution of the Victorian dog fancy', *Victorian Studies* 29, 1986, 227-253; K. Kete, *The Beast in the Boudoir: Pet-keeping in Nineteenth-Century Paris*, London: University of California Press, 1994; K. Grier, *Pets in America: A History*, Chapel Hill: University of North Carolina Press, 2006; N. Pemberton and M. Worboys, *Mad Dogs and Englishmen: Rabies in Britain, 1830-2000*, Basingstoke: Palgrave Macmillan, 2007.

[9] S. Jones, 'Framing animal disease: Housecats with Feline Urological Syndrome, their owners, and their doctors', *Journal of the History of Medicine and Allied Sciences* 52, 1997,

202-35; A. Cassidy, 'Vermin, victims and disease: UK framings of badgers in and beyond the bovine TB controversy', *Sociologia Ruralis* 52, 2012, 192-214.

[10] R. Kirk, "Wanted—standard guinea pigs': Standardisation and the experimental animal market in Britain ca. 1919–1947', *Studies in History and Philosophy of Biological and Biomedical Sciences* 39, 2008, 280-91

[11] C. Rosenberg, 'Disease in history: Frames and framers', *The Milbank Quarterly* 67, Supplement 1, 1989, 1-15.

[12] T. Newfield, 'Human-bovine plagues in the Early Middle Ages" *Journal of Interdisciplinary History* XLVI, 2015, 1-38.

[13] P. Phoofolo, 'Epidemics and revolutions: The rinderpest epidemic in late nineteenth-century southern Africa', *Past and Present* 138, 1993, 112-143.

[14] R. Waller, "Clean' and 'dirty': Cattle disease and control policy in Colonial Kenya, 1900-14', *Journal of African History* 45, 2004, 45-80.

[15] In the nineteenth century, the term 'infectious' had a relatively narrow definition, extending only to diseases that were directly or indirectly communicable. The term 'zoonosis' referred primarily to animal diseases, and only secondarily to human diseases acquired from an animal. Diseases transmissible from animals to man were simply referred to as such. Their mainstream labelling as zoonoses occurred in the context of 1950s World Health Organisation discussions on their control. There remains some ambiguity around the exact scientific definitions of 'zoonoses' and 'infectious diseases.' The origins of the term 'epizootic' have not been investigated, though its application to dramatic, rapidly spreading livestock diseases dates from at least the late eighteenth century. R Fiennes, *Zoonoses of Primates*, London: Weidenfeld and Nicolson, 1967, pp. 2-6; F. Condrau and M. Worboys, 'Second opinions: Epidemics and infections in nineteenth-century Britain', *Social History of Medicine* 20 (2007), 147-58.

[16] J. McEldowney, W. Grant and G. Medley, *The Regulation of Animal Health and Welfare: Science, Law and Policy*, London: Routledge, 2013.

[17] G. Fleming, *Animal Plagues: Their History, Nature and Prevention,* London: Chapman and Hall, 1871, pp. 1-32.

[18] W. Beinart, 'Vets, viruses and environmentalism: The Cape in the 1870s and 1880s', *Paideuma* 43, 1997, 227-52; A. Woods, *A Manufactured Plague: The History of Foot and Mouth Disease in Britain*, London: Earthscan, 2004.

[19] M. Worboys, 'Germ theories of disease and British veterinary medicine, 1860-1890', *Medical History* 35, 1991, 308-27; M. Harrison, *Contagion: How Commerce has Spread Disease*, Newhaven: Yale University Press, pp. 211-46.

[20] Newfield, 'Human-bovine plagues'.

[21] C. Gilmour, 'The 791 equine pestilence and its impact on Charlemagne's army', *Journal of Medieval Military History* 3, 2005, 23-45.

[22] Newfield, 'Human-bovine plagues'; Harrison, *Contagion*

[23] Harrison, *Contagion.*

[24] C. McShane and J. Tarr, *The Horse in the City: Living Machines in the Nineteenth Century*, Baltimore: John Hopkins University Press, 2007; A. Greene, *Horses at Work: Harnessing Power in Industrial America*, London: Harvard University Press, 2008.

[25] A. Woods, 'From practical men to scientific experts: British veterinary surgeons and the development of government scientific expertise, c1878-1919', *History of Science* li, 2013, 457-80.

[26] Beinart, 'Vets, viruses and environmentalism'; J. Fisher, 'Technical and institutional innovation in nineteenth century Australian pastoralism: The eradication of psoroptic mange in Australia', *Journal of the Royal Australian Historical Society* 84, 1998, 38-55; R. Peden, 'Sheep breeding in colonial Canterbury (New Zealand): A practical response to the

challenges of disease and economic change, 1850-1914, in Brown and Gilfoyle (eds.), *Healing the Herds*, pp. 215-31.

[27] C. Spinage, *Cattle Plague: A History*, London: Kluwer academic, 2003.

[28] Newfield, 'Human-bovine plagues'.

[29] T. Newfield, 'A Cattle panzootic in early fourteenth-century Europe', *Agricultural History Review* 57, 2009, 155-190; P. Slavin, 'The Great Bovine Pestilence and its economic and environmental consequences in England and Wales, 1318-50', *Economic History Review* 65, 2012, 1239-1266; S. De Witte and P. Slavin, 'Between famine and death: England on the eve of the Black Death – Evidence from paleoepidemiology and manorial accounts', *Journal of Interdisciplinary History* xliv, 2013, 37-60.

[30] K. Appuhn, 'Ecologies of beef: Eighteenth-century epizootics and the environmental history of Early Modern Europe', *Environmental History* 15, 2010, 268–287.

[31] L. Wilkinson, *Animals and Disease: An Introduction to the History of Comparative Medicine*, Cambridge: Cambridge University Press, 1992, pp. 35-64.

[32] C. Hannaway, 'The Societe Royale de Medicine and epidemics in the ancient regime', *Bulletin of the History of Medicine* 46, 1972, 257-73; J. Broad, 'Cattle Plague in Eighteenth-Century England', *Agricultural History Review* 31, 1983, 104-15; Wilkinson, *Animals and Disease*; P. Koolmees, 'Epizootic diseases in the Netherlands', in Brown and Gilfoyle (eds), *Healing the Herds*, pp. 19-41; D. Huenniger, 'Policing epizootics: Legislation and administration of cattle plague in eighteenth century northern Germany as continuous crisis management', in Brown and Gilfoyle (eds), *Healing the Herds*, pp. 76-91; D. Brantz, "Risky business': Disease, disaster and the unintended consequences of epizootics in 18th and 19th century France and Germany', *Environment and History* 17, 2011, 35-52.

[33] C. Huygelen, 'The immunization of cattle against rinderpest in eighteenth-century Europe', *Medical History* 41, 1997, 182-96.

[34] J. Fisher, 'The economic effects of cattle disease in Britain and its containment, 1850-1900', *Agricultural History* 52, 1980, 278-94; Worboys, 'Germ theories'; J. Fisher, 'British physicians, medical science and the cattle plague, 1865-6', *Bulletin of the History of Medicine* 67, 1993, 651-99; T. Romano, 'The cattle plague of 1865 and the reception of the germ theory', *Journal of the History of Medicine* 52, 1997, 51-80.

[35] T. Ofcansky, 'The 1889-97 rinderpest epidemic and the rise of British and German colonialism in eastern and southern Africa', *Journal of African Studies* 8, 1981, 31-38; C. Ballard, 'The repercussions of rinderpest: Cattle plague and peasant decline in colonial Natal', *International Journal of African Historical Studies* 19, 1986, 421-450; G. Campbell, 'Disease, cattle, and slaves: The development of trade Between Natal and Madagascar, 1875-1904', *African Economic History* 19, 1990-91, 105-33; H. Weiss, ''Dying cattle': Some remarks on the impact of cattle epizootics in the Central Sudan during the nineteenth century', *African Economic History* 26, 1998, 173-199; D. Doeppers, 'Fighting Rinderpest in the Philippines, 1886-1941' in Brown and Gilfoyle (eds), *Healing the Herds*, pp. 108-28; M. Barwegan, 'For better or worse? The impact of the veterinarian service on the development of agricultural society in Java (Indonesia) in the nineteenth century', in Brown and Gilfoyle (eds), *Healing the Herds*, pp. 92-107; S. Mishra, 'Beasts, murrains, and the British Raj: Reassessing colonial medicine in India from the veterinary perspective, 1860–1900', *Bulletin of the History of Medicine* 85, 2011, 587-619.

[36] Phoofolo, 'Epidemics and revolutions', 118.

[37] D. Gilfoyle, 'Veterinary research and the African rinderpest epizootic: The Cape Colony, 1896-1898', *Journal of Southern African Studies* 29, 2003, 133-54; E. Gargallo, 'A question of game or cattle? The fight against trypanosomiasis in Southern Rhodesia (1898-1914)', *Journal of Southern African Studies* 35, 2009, 737-53.

[38] Mishra, 'Beasts, Murrains'.

[39] P. Chakrabarti, 'Beasts of burden: Animals and laboratory research in Colonial India', *History of Science* 48, 2010, 125–152.

[40] D. Gilfoyle, 'Veterinary immunology as colonial science: Method and quantification in the investigation of horsesickness in South Africa, c1905-45', *Journal of the History of Medicine* 61, 2005, 26-65; K. Brown, 'Frontiers of disease: Human desire and environmental realities in the rearing of horses in nineteenth and twentieth-century South Africa', *African Historical Review* 40, 2008, 30-57.

[41] C. Mavhunga and M. Spierenburg, 'A finger on the pulse of the fly: Hidden voices of colonial anti-tsetse science on the Rhodesian and Mozambican borderlands, 1945–1956, *South African Historical Journal* 58, 2007, 117-141; K. Brown, 'From Ubombo to Mkhuzi: Disease, colonial science and the control of nagana (livestock trypanosomosis) in Zululand, South Africa, c1894-1953', *Journal of the History of Medicine and Allied Sciences* 63, 2008, 285-322; Gargallo, 'A Question of Game or Cattle'.

[42] P. Cranefield, *Science and Empire: East Coast Fever in Rhodesia and the Transvaal*, Cambridge: Cambridge University Press, 1991.

[43] C. Bundy, "We don't want your rain, we won't dip': Popular opposition, collaboration and social control in the anti-dipping movement, c1908-16', in W. Beinart and C. Bundy (eds), *Hidden Struggles in Rural South Africa*, London: Currey, 1987, pp. 191-221.

[44] A. Olmstead and P. Rhodes, *Arresting Contagion: Science, Policy, and Conflicts over Animal Disease Control*, Cambridge: Harvard University Press, 2015, pp. 251-77.

[45] A. Crosby, *The Columbian Exchange: Biological and Cultural Consequences of 1492*, Westport: Greenwood, 1972

[46] Fisher, 'Technical and institutional innovation'.

[47] W. Beinart, 'Transhumance, animal diseases and environment in the Cape, South Africa', *South African Historical Journal* 58, 2007, 17-41.

[48] J. Peires, ‘The central beliefs of the Xhosa cattle-killing’, *Journal of African History* 28, 1987, 43-63.

[49] C. Andreas, ‘The spread and impact of the lungsickness epizootic of 1853-57 in the Cape Colony and the Xhosa chiefdoms’, *South African Historical Journal* 53, 2005, 50-72.

[50] C. Hutson, ‘Texas fever in Kansas, 1866-1930’, *Agricultural History* 68, 1994, 74-104; A. Olmstead, ‘The first line of defense: Inventing the infrastructure to combat animal diseases’, *Journal of Economic History* 69, 2009, 327-357; Beinart, ‘Transhumance’.

[51] Woods, ‘From practical men’.

[52] J. Fisher, ‘The origins, spread and disappearance of contagious bovine pleuro-pneumonia in New Zealand’, *Australian Veterinary Journal* 84, 2006, 439-44.

[53] L. Newton, ‘CBPP in Australia: Some historic highlights from entry to eradication’, *Australian Veterinary Journal* 69, 1992, 306-17.

[54] J. Fisher, ‘To kill or not to kill: The eradication of contagious pleuro-pneumonia in Western Europe’, *Medical History* 47, 2003, 314–31.

[55] Woods, *Manufactured Plague*; Woods, ‘From practical men’.

[56] O. Stalheim, ‘The hog cholera battle and veterinary professionalism’, *Agricultural History* 62, 1988, 116-21; Woods, *Manufactured Plague.*

[57] L.A. Lomnitz and L. Mayer, 'Veterinary medicine and animal husbandry in Mexico: from empiricism to science and technology’, *Minerva* 32, 1994, 144-57.

[58] Woods, *Manufactured Plague.*

[59] K. Brown, ‘Tropical medicine and animal diseases: Onderstepoort and the development of veterinary science in South Africa 1908–1950’, *Journal of Southern African studies* 31, 2005, 513-529.

[60] J. Kastner, 'Scientific conviction amidst scientific controversy in the transatlantic livestock and meat trade', *Endeavour* 29, 2005, 78–83. K. Asdal, 'Making space with medicine', *Scandinavian Journal of History* 31, 2006, 255-269; Woods, 'From practical men'.

[61] Knab, 'Infectious Rats'.

[62] Woods, *Manufactured Plague.*

[63] Olmstead and Rhodes, *Arresting Contagion.*

[64] Beinart, 'Transhumance'.

[65] Phoofolo, 'Epidemics and revolutions'.

[66] Brown and Gilfoyle, 'Introduction'.

[67] Waller, "Clean' and 'dirty".

[68] P. Bartrip, *Myxomatosis: A History of Pest Control and the Rabbit*, Palgrave, London, 2008.

[69] H. Bazin, *Vaccination: A History from Lady Montagu to Genetic Engineering*, John Libbey Eurotext, 2011.

[70] L. Wilkinson, 'Glanders: medicine and veterinary medicine in common pursuit of a contagious disease', *Medical History* 25, 1981, 363-384; J. Derbyshire, 'The eradication of glanders from Canada', *Canadian Veterinary Journal* 43, 2002, 722-26; Mishra, 'Beasts, murrains'.

[71] L Van Sittert, 'Class and canicide in Little Bess: The 1893 Port Elizabeth rabies epidemic', *South African Historical Journal* 48, 2003, 207-234; Pemberton and Worboys, *Mad dogs*; P. Teigen, 'Legislating fear and the public health in Gilded Age Massachusetts', *Journal of the History of Medicine and Allied Sciences* 62, 2007, 141-170.

[72] K. Brown, *Mad Dogs and Meerkats: A History of Resurgent Rabies in Southern Africa*, Athens: Ohio University Press, 2011.

[73] S Jones, 'Plague's Third Pandemic: A History of Disease Ecology', Annual lecture in the history of health and medicine, Kings College London, 2015.

[74] P. Koolmees, 'Veterinary inspection and food hygiene in the twentieth century', in D. Smith and J. Phillips (eds), *Food, Science, Policy and Regulation in the Twentieth Century*, London: Routledge, 2000, pp. 53-68.

[75] A. Hardy, 'Animals, disease and man: making connections', *Perspectives in Biology and Medicine* 46, 2003, 200–15.

[76] D. Gilfoyle, 'Anthrax in South Africa: Economics, experiment, and the mass vaccination of animals, c1910-45', *Medical History* 50, 2006, 465-90; M. Cassier, 'Producing, controlling and stabilising Pasteur's anthrax vaccine: Creating a new industry and a health market', *Science in Context* 21, 2008, 253-78; S. Jones, *Death in a Small Package: A Short History of Anthrax*, Baltimore: John Hopkins University Press, 2010; J. Stark, *The Making of Modern Anthrax, 1875–1920: Uniting Local, National and Global Histories of Disease*, London: Pickering and Chatto, 2013.

[77] D. Brantz, 'Animal bodies, human health, and the reform of slaughterhouses in 19th century Berlin', in P.Y. Lee (ed.), *Meat, Modernity and the Rise of the Slaughterhouse*, London: University of New Hampshire, 2008, pp. 71-85; Tatsuya Mitsuda, 'The development of veterinary medicine in Germany, circa 1770-1930', unpublished manuscript, 2014.

[78] J. Gignilliat, 'Pigs, politics and protection: The European boycott of American pork, 1879-1891', *Agricultural History* 35, 1961, 3-12; J. Cassedy, 'Applied microscopy and American pork diplomacy: Charles Wardell Stiles in Germany 1898-1899', *Isis* 62, 1971, 4-20.

[79] K. Waddington, *The Bovine Scourge: Meat, Tuberculosis and Public Health, 1850–1914,* Woodbridge: Boydell Press, 2006; D. Berdah, 'Meat, public health and veterinary expertise: Eating beef from tuberculous bovines in France, late nineteenth century', unpublished manuscript, 2013.

[80] L. Wilson, ‘The historical riddle of milk-borne scarlet fever’, *Bulletin of the History of Medicine* 60, 1986, 321-42; J. Steere-Williams: ‘The perfect food and the filth disease: Milk-borne typhoid and epidemiological practice in late Victorian Britain’, *Journal of the History of Medicine and Allied Sciences* 65, 2010, 514-45.

[81] P. Atkins, ‘The pasteurisation of England: the science, culture and health implications of milk processing, 1900-1950’ in D. Smith and J. Phillips (eds), *Food, Science, Policy, and Regulation in the Twentieth Century*, London: Routledge, 2000, pp. 37-51; M. French and J. Phillips, *Cheated not Poisoned? Food Regulation in the United Kingdom, 1875-1938,* Manchester: Manchester University Press, 2000, pp. 158-84; B. Orland, ‘Cow’s milk and human disease: Bovine tuberculosis and the difficulties involved in combating animal diseases’, *Food and History* 1, 2003, 179–202; S. Jones, *Valuing Animals: Veterinarians and their Patients in Modern America*, Baltimore: John Hopkins University Press, 2003, pp. 63-90; S. Jones, ‘Mapping a zoonotic disease: Anglo-American efforts to control bovine tuberculosis before World War I’, *Osiris* 19, 2004, 133-48; G. Colclough, 'Filthy vessels': milk safety and attempts to restrict the spread of bovine tuberculosis in Queensland’, *Health & History* 12, 2010, 6-26.

[82] D. Pritchard, ‘A century of bovine tuberculosis 1888-1988: Conquest and controversy’, *Journal of Comparative Pathology* 99, 1988, 357-99; D. Berdah, ‘Between human medicine and veterinary medicine: The fight against bovine tuberculosis in France and in the United Kingdom, 1920-60’, unpublished draft, 2013.

[83] K. Waddington, ‘To stamp out ‘so terrible a malady’: Bovine tuberculosis and tuberculin testing in Britain, 1890-1939’, *Medical History* 48, 2004, 29-48; Olmstead and Rhodes, *Arresting Contagion*, pp. 278-301.

[84] E. Madden, *Brucellosis: A History of the Disease and its Eradication from Cattle in Great Britain*, London: MAFF, 1984; R. Kaplan, ‘The politics of the herd: Big government and

libertarian imperative in United States brucellosis eradication, 1945 – 1985, *Western Humanities Review*, 2015, forthcoming.

[85] P. Atkins, 'Milk consumption and tuberculosis in Britain, 1850-1950' in A Fenton (ed) *Order and Disorder: The Health Implications of Eating and Drinking in the Nineteenth and Twentieth Centuries*, East Linton: Tuckwell Press, 2000, pp. 83-95; B. Orland, 'Cow's milk'; Olmstead and Rhodes, *Arresting Contagion.*

[86] D. Cousins and J. Roberts, 'Australia's campaign to eradicate bovine tuberculosis: The battle for freedom and beyond', *Tuberculosis* 81, 2001, 5-15; P. Robinson, 'A history of bovine tuberculosis eradication policy in Northern Ireland', *Journal of Epidemiology and Infection*, 2015, forthcoming.

[87] W. Grant, 'Intractable policy failure: The case of bovine TB and badgers', *British Journal of Politics and International Relations* 11, 2009, 557-73; A. Cassidy, 'Vermin'; G. Enticott, 'Biosecurity and the bioeconomy. The case of disease regulation in the UK and New Zealand', in A. Morley and T. Marsden (eds), *Researching Sustainable Food: Building the New Sustainability Paradigm*, Earthscan: London, 2014, pp. 122-142.

[88] Woods and Bresalier, 'One Health'.

[89] R. Mason Dentinger, 'Patterns of infection and patterns of evolution: How a malaria parasite brought "monkeys and man" closer together in the 1960s', *Journal of the History of Biology*, 2015, forthcoming.

[90] C. Jerolmack, 'How pigeons became rats: The cultural-spatial logic of problem animals', *Social Problems* 55, 2008, 72-94.

[91] A. Hardy, *Salmonella Infections, Networks of Knowledge, and Public Health in Britain, 1880-1975*, Oxford: Oxford University Press, 2014; Koolmees, 'Veterinary inspection'.

[92] H. Ritvo, 'Animal planet', *Environmental History* 9, 2004, 204-20.

[93] A. Woods, ‘The farm as clinic: Veterinary expertise and the transformation of dairy farming, 1930-50’, *Studies in History and Philosophy of Biological and Biomedical Sciences* 38, 2007, 462-87.

[94] Jones, *Valuing Animals*; M. MacKay, ‘The rise of a medical specialty: The medicalisation of elite equine care c.1680 – c.1800’, unpublished PhD thesis, University of York, 2009; A. Gardiner, ‘Small animal practice in British veterinary medicine’, unpublished PhD thesis, University of Manchester, 2010; A. Woods and S. Matthews, ‘‘Little, if at all, removed from the illiterate farrier or cow-leech’: The English veterinary surgeon, c. 1860-85, and the campaign for veterinary reform’, *Medical History* 54, 2010, 29-54; Upex and Dobney ‘More than just mad cows’.

[95] M. Bresalier and M. Worboys, “Saving the lives of our dogs’: The development of canine distemper vaccine in interwar Britain’, *British Journal for the History of Science* 47, 2014, 305–334.

[96] S. Jones, ‘Framing’; A. Gardiner, ‘The animal as surgical patient: A historical perspective in the 20th Century’, *History and Philosophy of the Life Sciences* 31, 2009, 355-376; M. Schlünder and T. Schlich, ‘The emergence of “implant-pets” and “bone-sheep”: Animals as new biomedical objects in orthopedic Surgery (1960s-2010)’ *History and Philosophy of the Life Sciences* 31, 2009, 433-466; C. Degeling, ‘Negotiating value: Comparing human and animal fracture care in industrial societies’, *Science, Technology, & Human Values* 34, 2009, 77-101.

[97] N. Clayton, "Poorly co-ordinated structures for public science that failed us in the past’? Applying science to agriculture: A New Zealand case study’, *Agricultural History* 82, 2008, 445-467.

[98] Beinart, ‘Transhumance’; K. Brown, ‘Poisonous plants, pastoral knowledge and perceptions of environmental change in South Africa, c. 1880-1940’, *Environment and History* 13, 2007, 307-332.

[99] R Peden, ‘Sheep breeding’.

[100] M. Schwartz, *How the Cows Turned Mad*, London: University of California Press, 2003; K. Kim, *The Social Construction of Disease: From Scrapie to Prion*, London: Routledge, 2006.

[101] Jones, *Valuing Animals*, pp. 91-114; M. Finlay, ‘Hogs, antibiotics and the industrial environments of postwar agriculture’, in S. Schrepfer and P. Scranton (eds) *Industrializing Organisms*, London: Routledge, 2004, pp. 237–60; K. Smith-Howard, ‘Antibiotics and agricultural change: Purifying milk and protecting health in the postwar era’, *Agricultural History* 85, 2010, 327-51; A. Woods, ‘Is prevention better than cure? The rise and fall of veterinary preventive medicine, c1950-80’, *Social History of Medicine* 26, 2013, 113-131.

[102] A. Woods, ‘Science, disease and dairy production in Britain, c1927-80’, *Agricultural History Review* 62, 2014, 294-314.

[103] Newfield, ‘Domesticates’, 117.